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FARM WATER SUPPLIES

Their Inspection, Protection and Purification

Published at Helena, by the State Board of Health.

"Public health is purchasable. Within natural limitations a community can determine its own death rate."

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Sanitary Qualities of the Farm Water Supply

By W. M. Cobleigh, Chemist and Director
Division of Water and Sewage

INTRODUCTION.

No systematic investigation of the farm water supplies of Montana has been made. The data at hand is more or less fragmentary. Sufficient is known, however, to indicate that many water supplies derived from various types of farm wells are not in a satisfactory condition from the sanitary aspect.

A large proportion of the private water supplies of the state cannot be recommended for human consumption. This condition arises through ignorance of the principles of sanitation that apply to the location, construction and operation of private water supplies.

The purpose of this bulletin is to provide the information required in conducting sanitary investigations of private water supplies with the hope that local and county health officers will become interested and proficient in this phase of public health work.

It is believed that health officers should investigate the private water supplies of their districts and disseminate information that will assist individual owners in assuming more direct care and responsibility for the purity of their own water supplies.

Periodic investigations of all private water supplies by the state health department or even by a local health department are quite out of the question. It is therefore necessary to foster individual responsibility by the dissemination of a working knowledge of the principles of sanitation. If each individual farmer knew how to select a proper location for a well, understood how to protect a well by adequate construction, and appreciated the care necessary in the sanitary operation of a well water supply, there would be fewer unsatisfactory private supplies today.

The subject of the farm water supply is presented in this circular entirely from the sanitary aspect. Some private water supplies are unsatisfactory because of a high alkali or mineral content. Information on the alkali waters of Montana is contained in another publication.

Publications of the U. S. Public Health Service and bulletins of various state boards of health have been used in the preparation of this circular. The illustrations showing types of wells were adopted from a circular by the Minnesota State Board of Health.

Definition of Terms. A water suitable for all domestic uses should possess certain well defined physical, chemical and bacteriological qualities. From the physical standpoint, a water should contain no substances that produce an unusual color or bad odors or disagreeable tastes. The water should be free from suspended matter and be clear and sparkling. A water that is at all abnormal in its physical characteristics arouses suspicions and is undesirable even when it can be shown that such water contains no injurious substances.

The qualities of a domestic water are satisfactory from the chemical standpoint when it does not contain excessive amounts of so-called alkali salts, or organic matter which may indicate the presence of contamination. Poisonous chemical salts should also be absent. A natural water seldom contains such substances. Occasionally a water contains salts of lead formed by the solvent action of water on lead pipes.

In certain western states underground waters often contain alkali salts in solution in amounts that have a marked physiological effect. This phase of the farm water problem will not receive consideration in this circular.

From the bacteriological standpoint, a water is not safe for drinking unless it is free from germs that cause disease, with special reference to the germs that cause the usual water borne diseases. The bacteriological qualities will be discussed more at length in another portion of this circular.

Whipple recommends the following definitions of certain terms applied to water mixed with foreign substances:

Water
- Polluted
  - Befouled—Contains matter tending to make it foul, unsightly, or ill-smelling but which is not of excrementitious origin.
  - Contaminated—Contains excreta from human beings or animals.
- Infected — Contains germs of disease.
- Poisoned — Contains a poisonous chemical substance.

It will be observed that the word pollution is a general term used to designate all substances that may become mixed with water. These include the waste products of industrial processes, surface drainage from the watershed of a river during freshets and excreta from human beings, birds and farm animals.

It is desirable to divide polluting water into two classes. The term befoulment is used to designate the substances that make a water foul, unsightly or ill-smelling, but which are not of excrementitious origin. The term contamination, on the other hand, represents in a restricted sense only matter of excrementitious origin whether from human beings or animals. A contaminated water does not necessarily contain germs that cause water borne diseases.

A water that carries infection actually contains the germs of disease.

The term poisoned represents a chemical salt or substance that is poisonous in the usual acceptance of that word.

SOURCES OF FARM WATER SUPPLIES.

The farm water supplies of Montana come from various sources classified below:

I. Surface Water Supplies.
   - (1) Rivers and mountain streams.
   - (2) Lakes and ponds.
   - (3) Irrigation ditches.
   - (4) Cisterns filled from streams and ditches.
   - (5) Cisterns filled with rain water.
   - (6) Cisterns filled with ice.
   - (7) Stored surface water.

II. Underground Water Supplies.
   - (1) Springs.
   - (2) Wells—dug, bored, drilled, driven.

The most important factor governing the sanitation of water supplies is the proper control of the environment as it relates to the disposal of human and animal excreta. Further factors are a proper location for the supply and the sanitary operation of the water system.

Factors Governing the Sanitation of Private Water Supplies.

Typhoid fever and dysentery are the diseases most apt to be conveyed by water in Montana. It has been shown that typhoid fever is caused by minute forms of vegetable life known as typhoid germs. In order to cause typhoid fever, these germs must get into the human body. They gain entrance to the body through the mouth and are often

conveyed by infected water and food as well as by direct contact with infected matter. When a person contracts typhoid fever, nature musters forces which tend to effect a cure. The germs which originally caused the disease multiply in the body, but during the progress of the illness, the germs are eliminated in great numbers in the discharges from the bowel and bladder of the patient.

Typhoid fever is peculiar to man and does not affect the lower animals. The human body is apparently the only natural breeding place for typhoid germs and, therefore, it follows that these germs are only to be found in nature in the bodies of infected persons, and in the excreta of persons sick with typhoid, or of persons who harbor the germs and who are known as "typhoid carriers." Consequently, if a person contracts typhoid fever, it means that he has swallowed some comparatively fresh discharges from a typhoid patient or "typhoid carrier." The discharges from a typhoid fever patient or "carrier" contain such enormous numbers of germs that only a small amount of such contamination reaching a water supply may seriously infect a comparatively large volume of water.

It is not within the scope of this circular to record designs for approved sanitary sewage disposal devices. It is sufficient here to emphasize the reasons why the spreading of human excreta is dangerous and to indicate clearly the necessity of the proper disposal of excreta in its relation to safe water supplies.

The information required is clearly stated in Bulletin 68, United States Public Health Service, by Lumsden, Stiles and Freeman.

"Among the most important diseases caused by living poisons or germs, contained in and spread by human excreta, are typhoid fever, dysentery, Asiatic cholera, tuberculosis, hookworm disease, and round worm, eelworm and tapeworm diseases."

"The Ways Human Filth Is Spread. It is easy to understand that human filth is dangerously spread under the conditions generally found at unsewered homes. Upon leaving the body, human excreta may be spread around by various means, of which the following are the most important:

By water, through surface washing or subsoil seepage.
By the hands or feet of persons or by animals.
By flies and other insects.

Water. Rain or other water can carry filth into drinking water, either by washing over the ground or by seeping through the ground into a well, spring, stream or lake. Tubes left by decayed tree roots and the burrows of insects or of cray-fish or of worms may act as channels to carry the filth considerable distances underground. Water supplies can be-

come contaminated by excreta conveyed on the hands or feet of persons, on the feet and bodies of poultry and of other animals, and by worms and insects. Water contaminated with human excreta, if used for washing certain foods or for washing vessels used for storing or handling foods—milk vessels being particularly important in this connection—will spread filth to foods. Thus water can serve both directly and indirectly as an agent in the spread of human excreta with the various disease germs which such matter may contain, from person to person."

From what has been said, it is evident that water borne diseases are preventable. The problem involves the adoption of measures which will prevent excreta from reaching the mouths of persons through the agency of water. It follows, therefore, that if the farm water supply is to be perfectly safe, it must have a sanitary environment and be properly constructed and operated in order to prevent excreta from reaching the water.

Sanitation of Surface Water Supplies.

Streams and Lakes. In the early days in Montana the first settlers in the mountainous portions of the state naturally established their farm habitations on the banks of mountain streams which furnished adequate supplies of pure water for irrigation and all domestic purposes. The natural qualities of mountain water make it very desirable for drinking and general household use. It was comparatively a safe practice to use such waters for household purposes when there were only a few settlers in the valleys. This was especially true when it happened, as it often did, that there was only one habitation on the same stream or creek.

However, the sanitary aspect of the practice of using surface water for drinking changes immediately as soon as several habitations are established one above the other on the same stream. Recognizing the principle that a water containing human excreta is unsafe for drinking, it is evident that there is a decided element of risk in using a surface water below human habitations as a source of domestic supply. Excreta may find its way directly into such a stream or even contamination anywhere on the drainage area may be carried to the stream during rain storms or spring freshets.

It follows that if a surface water is to be considered perfectly safe for drinking, it must come from a stream or lake above all human habitations. In fact, visitations by camping, fishing and picnic parties above the source of water supply introduce decided elements of risk.

Consequently, it would be advisable to limit the use of untreated surface waters for domestic purposes to those furnished by drainage areas which are never visited by human

beings. Further, the pasturing of farm animals on a drainage area furnishing water for domestic purposes, introduces certain elements of risk which are difficult to measure under the usual varying conditions.

Irrigation Ditches. In some sections of the state water from irrigation ditches is used for domestic purposes. This is a common practice in regions where the underground water supplies contain excessive amounts of alkali and in consequence have undesirable properties. As a rule, irrigation ditches are subject to contamination and, therefore, untreated surface waters from such sources are seldom safe. Some one of the forms of purification recommended in a subsequent part of this circular should be adopted.

Cisterns Filled From Streams and Irrigation Ditches. Farm water supplies are sometimes secured by filling cisterns with surface water obtained from streams and irrigation ditches. Special attention should be directed to the purity of the water used for this purpose. The principles governing the purity of surface waters should be applied in this case and if the sanitary qualities of the water so used are doubtful, the water should be purified before it is used for drinking. Full directions for purifying water in small quantities are given in a subsequent section of this circular.

Cisterns Filled With Rain Water. For information on the storage of rain water for domestic uses and the construction of cisterns, the reader is referred to Circular 66—Montana Agricultural Experiment Station; The Domestic Water Supply on the Farm, by H. E. Murdock. A copy of this circular can be obtained from the director of the Experiment Station, Bozeman.

Cisterns Filled With Ice. In regions where the surface waters are polluted and where the underground waters are unsatisfactory because of a high alkali content, water obtained from melted ice is often used for drinking and other domestic purposes. Ice is placed in large cisterns and allowed to melt. The use of adequate ice supplies on the farm is so important that a subsequent section of this circular is devoted to the principles governing the production and utilization of sanitary ice.

Stored Surface Water. In some sections of the state there is an abundance of surface water in the spring of the year. Later in the season there is little or no surface water available. The natural contours are often well adapted to the cheap construction of storage reservoirs which could be used to impound the extra surface water available in the spring of the year.

For information on the construction of farm reservoirs, the reader is referred to Farmers' Bulletin No. 828, United States Department of Agriculture, by Samual Fortier. Free

copies of this bulletin can be obtained from the Division of Publications, U. S. Department of Agriculture, Washington, D. C.

The principles governing the sanitary qualities of surface waters in general should be applied to the water stored in farm reservoirs provided the same is to be used for domestic purposes.

Factors Governing Sanitation of Underground Waters.

It is apparent that surface waters are, as a general rule, subject to contamination. Therefore, there are comparatively only a few favored localities where it is advisable to use unpurified surface waters for human consumption. It follows that the use of underground waters as sources of supply for domestic water systems is very general. Ground water is secured for household purposes through the construction of wells of various types such as dug, bored, drilled or driven.

Types of Wells. The types of wells that are common in Montana are dug, bored, driven and drilled. M. L. Fuller in Water Supply Paper No. 255, United States Geological Survey, has described each of these types of wells and states the conditions to which each type is best adapted. The table below is copied from Water Supply Paper No. 255.

Type of Well	Description	Conditions to Which Well Is Best Adapted.
Dug	Generally circular excavations, 3 to 6 feet in diameter, dug or blasted by hand and curbed with wood or with stones or bricks laid without cement.	Adapted to localities where the water is near the surface, especially where it occurs as small seeps in clayey materials and requires extensive storage space for its conservation. Should not be near sources of pollution.
Bored	bored with various types of Augers from 2 inches to 3 feet in diameter, rotated and lifted (together with the earth) by hand or horse power, curbeed with wood, cement, or tile sections, with open or cemented joints and more rarely, with iron tubing	Adapted to localities where the water is at slight or medium depths and to materials similar to those in which open wells are sunk
Driven	Small iron tubes, usually 1¼ to 4 inches in diameter and provided with points and screen, driven downward by hand or by simple hand or horse-power apparatus.	Adapted to soft and fine materials, especially to sands and similar porous materials carrying considerable water at relatively slight depths. Particularly desirable where upper soil carries polluting matter.

Standard Drilled.....	Sunk by precussion of heavy drill, 1½ to 12 inches or more in diameter, lifted and dropped from portable rig or derrick by horse or steam power. Cased with iron pipe in soft materials; usually not cased in rock. Drillings removed by long bucket with valve in bottom.	Can be used to advantage in all but the softest materials, but is particularly adapted to rock work, especially at great depths, being cheaper and quicker than other methods of drilling in rock.

It is plain that when a farm habitation is first established on new ground far removed from other habitations that the underground water in the vicinity is free from excreta and, therefore, is a safe source of water supply from the sanitary aspect. Underground waters may have a high alkali content and be unsatisfactory for domestic use on that account but this is a water problem which is not discussed in this circular.

Underground water supplies can be maintained in their original state of purity by adopting practical means of preventing excreta and other polluting materials from reaching the water. This can be accomplished by the use of properly constructed and operated sewage disposal systems and by adequately protecting the sources of water supply. The necessities for the safe disposal of human excreta have already been emphasized.

Turning attention next to methods of protecting the sources of water supply in order to prevent excreta from reaching the water, it is apparent that much depends on the location, construction and operation of the well from which water is secured for domestic use.

Location. A well should be located as far as possible from privies, cesspools, or other sources of contamination. Local conditions must be studied carefully in selecting a proper site for a well. The character of the soil and subsoil, the direction of the flow of underground water with respect to sewage disposal systems, the distance of the water table below the surface and the direction of surface drainage are important considerations.

The location should be selected so that there will be no surface slopes toward the well. This will prevent drainage from the surface from reaching the water. Lastly, a convenient location for the well should be selected so that the water may be distributed with a minimum amount of labor.

Construction. In the construction of a well, special attention should be given to the cover, casing, and curb. The cover should be tight so that water spilled on the top cannot pass into the well and carry impurities to the water supply.

The curb should be constructed of concrete and extend several inches above the ground in order to prevent contamination of the well by surface drainage. The casing should be water tight for a number of feet below the surface of the ground. This will prevent the contamination of the well by infiltration of impure surface water. There is a natural purification of water as it moves downward through soil. However, it is important that there should be a layer of soil of sufficient depth between the surface of the ground and the water bearing stratum to completely purify the impure surface water that may reach the well by infiltration. The proper construction of the casing will prevent the infiltration of surface water through a depth of soil that is not sufficient for its adequate purification.

Operation. The proper management of the well is of great importance. Kitchen waste and other polluting material should not be thrown on the surface of the ground near the well. The pump should be maintained in good working order. There is danger of polluting a water supply when the operation of "priming" a pump is necessary. The water used in "priming" may be impure and thus the entire supply may become contaminated. It is important that the cover, curb, and casing should be kept in perfect repair so that each may fulfill its proper function in protecting the water supply.

Protection of Wells. The principles governing the protection of wells as previously stated are illustrated in the figures which follow.

Figure 1 illustrates a properly constructed and located dug well. The well is provided with a water tight cover which prevents contamination entering the water directly. The curb and casing are properly designed and constructed. The construction as shown prevents pollution by surface drainage and by infiltration. The contamination from the sources shown cannot pass to the well directly but must filter through a considerable layer of soil before passing into the underground water supply. Filtration through a considerable layer of soil is a purifying process. However, an undue burden should not be placed on the filtering medium. Hence, excreta in the privy should not come in direct contact with the soil. The figure shows a fly proof receptacle privy. The type of privy shown can be classed as sanitary. The open pit privy cannot be recommended as a safe means of disposal of excreta, and must be classed as insanitary. The well is properly located on high ground above the barnyard and privy. This prevents pollution of the well by surface drainage.

Figure 2 illustrates an improperly located and constructed dug well and a very insanitary privy. The well site is on a ground lower than the barnyard and privy. Surface drain-

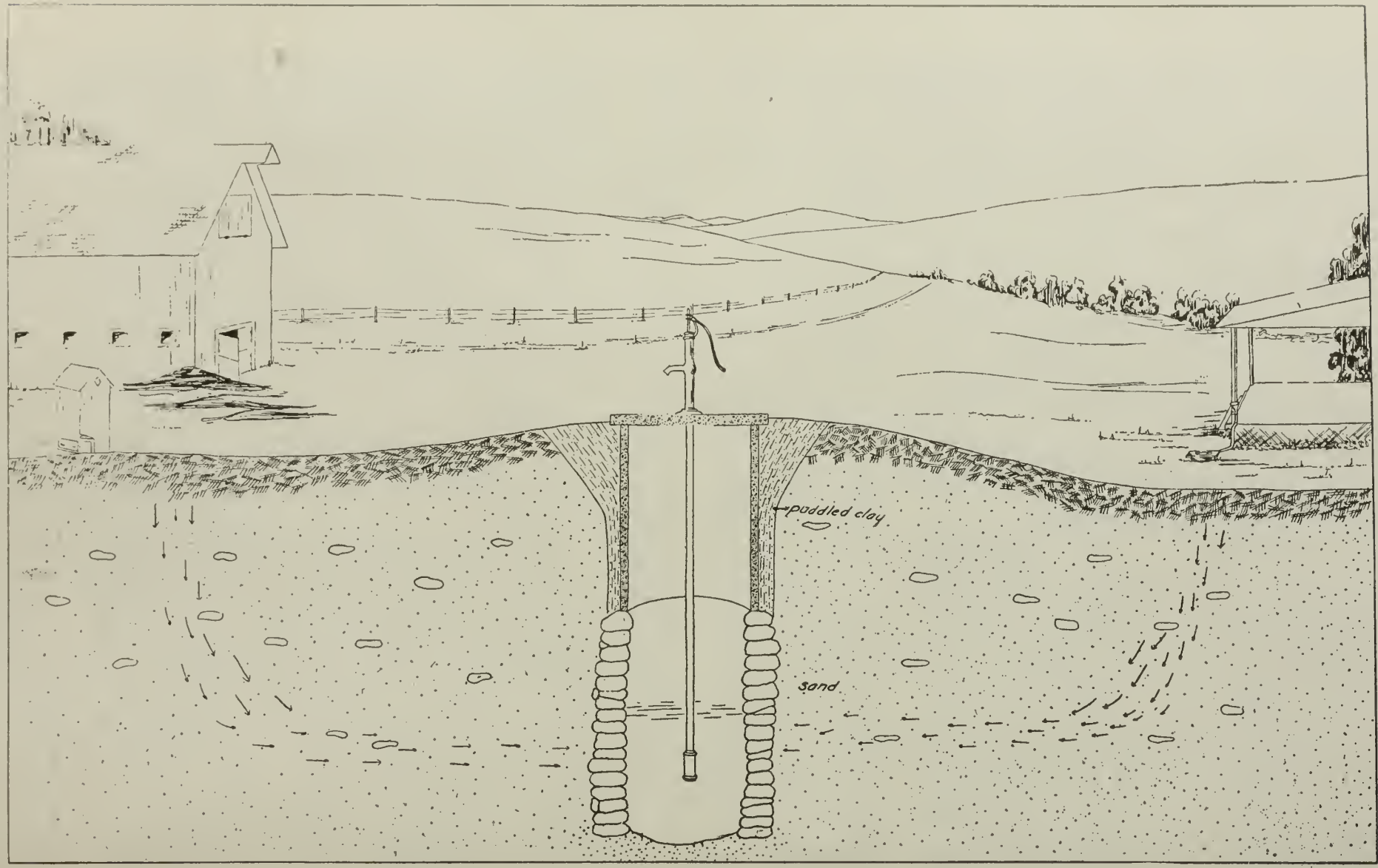


FIGURE I

Properly Constructed and Located Dug Well. This Is Not the Manner in Which Contamination Ordinarily Reaches a Well. The Soil Can Usually Hold Back Most of the Impurities Except Where Fissures Occur in Limestone Formations.

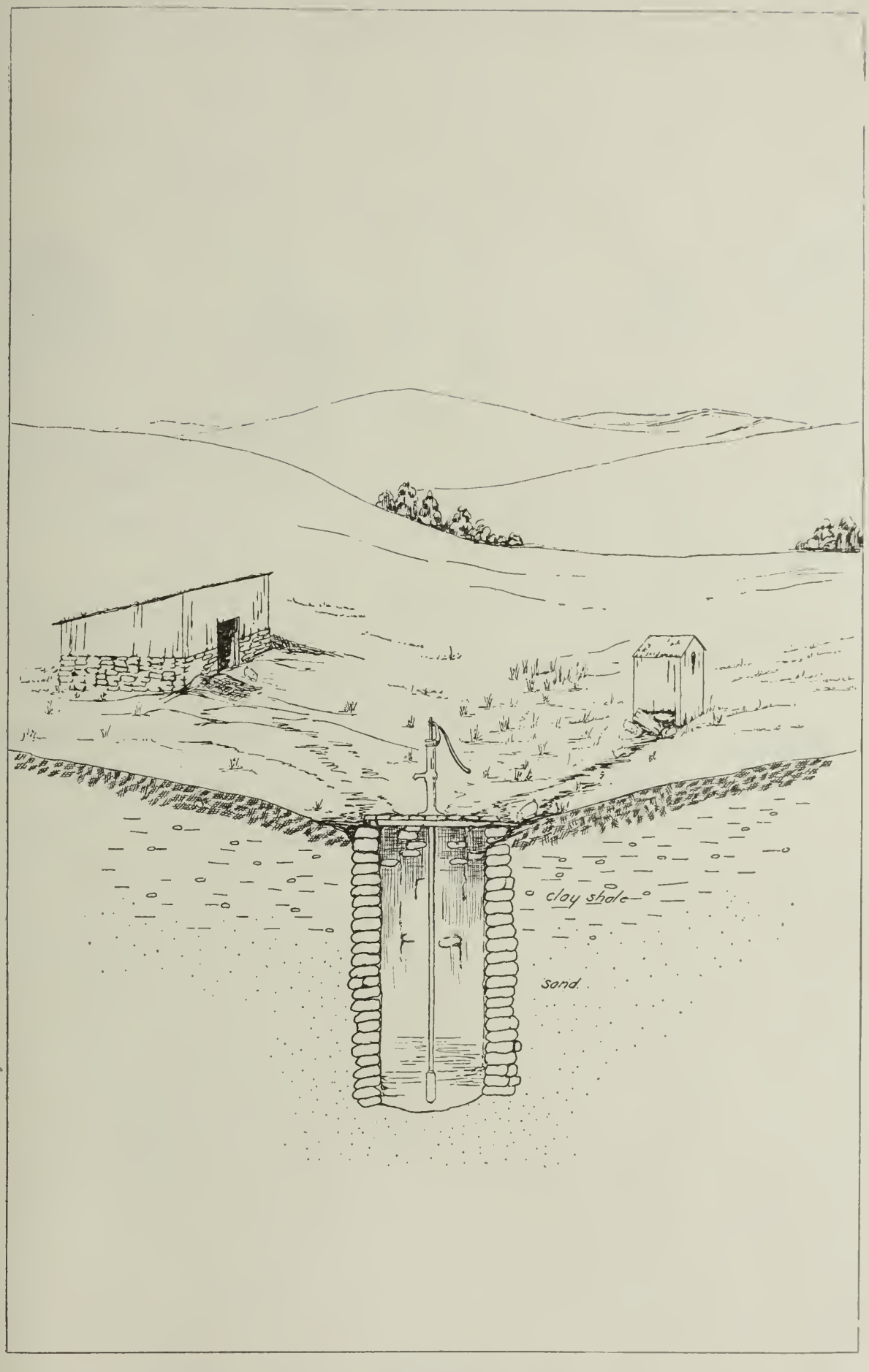


FIGURE II.

Improperly Constructed and Located Dug Well. Usual Method by Which a Dug Well Becomes Contaminated.

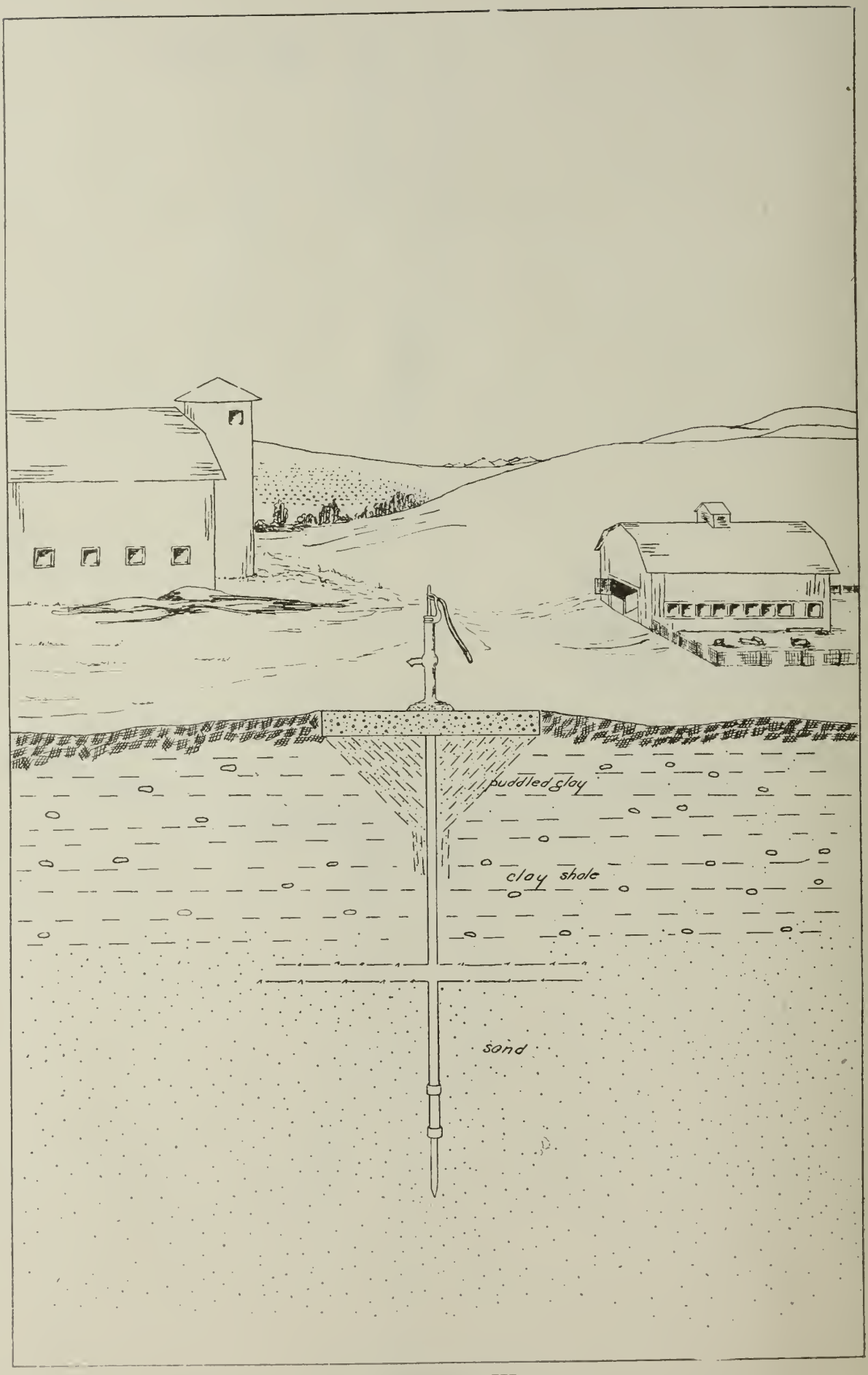


FIGURE III

Properly Constructed and Located Tubular Wiel.

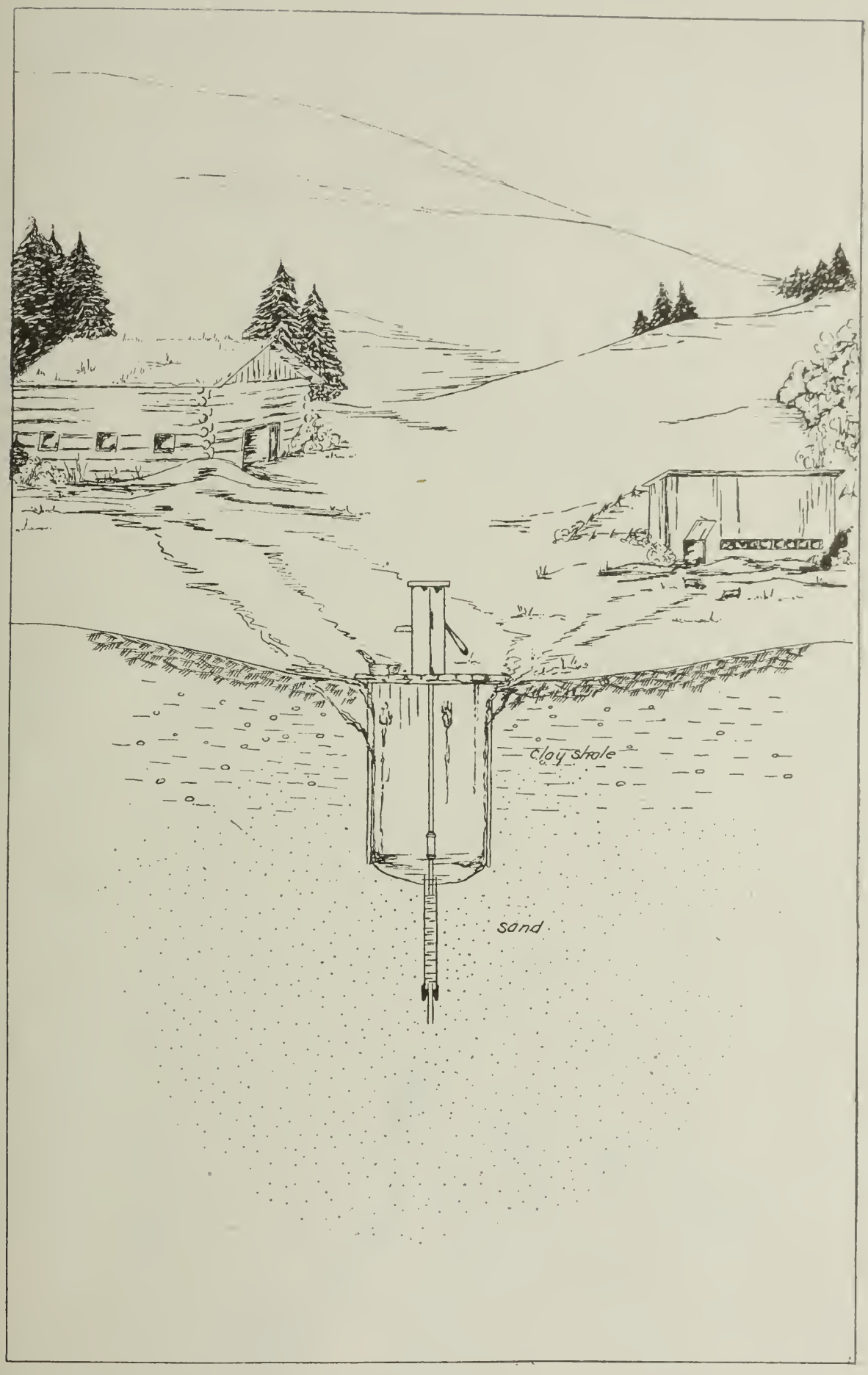


FIGURE IV.

Improperly Constructed and Located Tubular Well.

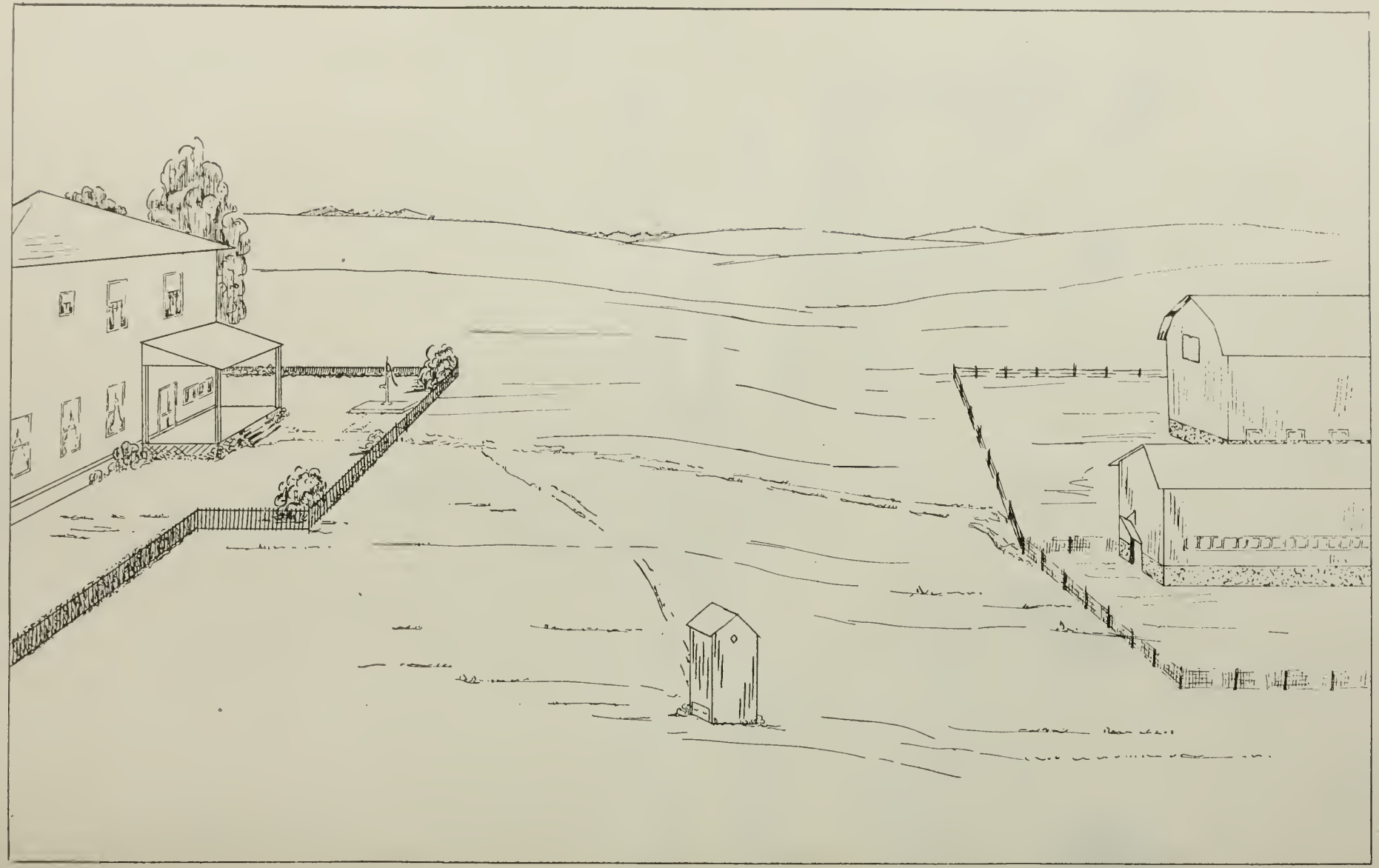


FIGURE V.

Farm Habitation Showing a Sanitary Receptable Privy and a Properly Located and Constructed Well.

FIGURE VI.

Farm Habitation Showing an Unsanitary Privy of the Open Pit Type and an Improperly Located and Constructed Well.

age can pass directly to the well. The curbing and casing are not adequate to protect the well from pollution by infiltration of impure water through the casing. The well cover is not water tight. The privy is very insanitary in its construction. It is the open pit type and is not fly proof. The soil surrounding the privy is contaminated with excreta. There is great danger that the excreta will be spread to the water supply.

Figures 3 and 4 show properly and improperly located and constructed tubular wells. It is generally taken for granted that tubular wells are quite sanitary. However, figure 4 indicates that very definite precautions must be taken to prevent the contamination of tubular wells.

Figure 5 illustrates a farm habitation. The well is conveniently located near the house and on ground higher than any nearby sources of contamination. The privy is what is called the receptacle type and would be classed as sanitary. With a privy of this character, there is little or no soil contamination.

Figures 6 illustrates a farm habitation with very insanitary provisions for the water supply. The privy is the open pit type and the soil around the privy could become grossly contaminated. The contaminated soil could be carried directly to the well top and since the well top is improperly constructed, the well would soon become contaminated. The well is improperly located, drainage from the barnyards and the privy could pass directly to the well.

In regions where the water table is very near the surface of the ground, the tubular well has decided advantages over the dug well. This is particularly true where there is more or less surface pollution. In fact, shallow dug wells are very difficult to protect properly. Again, the tubular well can pierce a deeper water bearing stratum than the dug well. The writer has made a comparison of these two types of wells under rather unusual circumstances.

Comparison of Dug and Tubular Wells.

A dug well, twenty-two feet deep, was cased with loosely piled stones which only came to the surface of the ground and thus provided an inadequate curb. This construction did not prevent pollution of the water by surface drainage and infiltration on occasions when the surrounding lawn was irrigated from a contaminated irrigating ditch. The top, made of ordinary boards, was not water-tight. This type of top allowed contamination to enter the water directly. That this was possible is indicated by the fact that chicken manure was frequently deposited on the well top, and by the fact that the well was located on a direct path between the privy and the house. Contaminated soil around the privy could easily be carried on the shoes of individuals

walking from the privy across the well top to the house. Kitchen waste thrown near the well made the ground around about more or less impure. An inspection of the well was made and a chemical analysis of the water of the well was secured.

After this investigation, it was decided to abandon the well, and construct a driven well. The new driven well was located not over ten feet from the site of the dug well which was filled up before the driven well was constructed. The driven well was 22 feet deep.

Comparative analyses of samples of water from both wells are tabulated below:

	Parts per Million	
	Dug Well	Driven Well
Albuminoid Ammonia	.64	.035
Free Ammonia	.31	.015
Nitrites	.025	None
Nitrates	2.6	3.6
Chlorine	13.4	9.7

The above data shows a great difference between the sanitary qualities of the normal ground water obtained from the driven well and the water in the improperly constructed and operated dug well which had become contaminated through twenty years of use. These data show very strikingly, the necessity of protecting an underground water supply and further indicate very clearly the advantage of a tubular well over a dug well in a locality where there is much surface pollution, and where the water table is near the surface of the ground.

Purification of Water in Small Quantities.

When through inadequate methods of protection, a farm water supply does become contaminated and unsafe for domestic use, it is advisable to purify the water in small quantities until the water system can be permanently protected from further pollution. Pending changes in location, environment or operation, that will insure a safe drinking water, small quantities can easily be purified for drinking.

Camping and picnic parties often use surface waters for drinking. When such water is secured at a point below human habitations or any other sources of contamination, there is a risk involved which should not be assumed. Waters of this character should be purified before they are used for human consumption.

Purification by Heating. The ordinary method of purifying water is by heating. Dr. Evans says, "Boiling kills the typhoid bacilli. It also drives off the gas and makes the water flat and tasteless. It is not necessary to boil water to kill typhoid bacilli. One hundred and fifty degrees for 30 minutes will kill them. If water is heated until bubbles

begin to form on the side of the vessel and set on the warm stove for 15 minutes, the typhoid bacilli will be killed and the water will not taste cooked." This operation can be carried out conveniently by using a clean wash boiler.

Disinfection With Chemicals. Typhoid germs can be destroyed by disinfection with chemicals such as chlorine, chloride of lime, iodine and hálazone. For purifying small quantities of water in camp or on the farm, iodine is probably more convenient than chlorine or chloride of lime. Bachmann, of the California State Board of Health, recommends the following method: "To one quart of clear water, add three drops (such as is obtained with the ordinary eye-dropper) of tincture of iodine. To waters which are cloudy or which contain considerable sediment, six drops may be needed. Iodine should be added until a slight but distinct brown color is noticeable. Allow the iodine to react for fifteen minutes, after which add a very small pinch of sodium thiosulphate or hypo—the chemical used for fixing in photographic work—to destroy residual iodine. The water will regain its original appearance.

"As color appearance is the essence of disinfection, a clear glass jar should be used. If the water is disinfected in a canteen or other invisible receptacle, the color may be observed in a drinking glass. The fifteen minute interval between addition of chemicals is very essential. Sterilization is not complete in less time. The amount of hypo used should be kept at a minimum, as overdosing will impart a slight bitter after-taste. The chemicals as recommended in the above amounts are not injurious to health."

Halazone. The public is indebted to Drs. Dakin and Dunham for halazone and its use in treating water supplies. Halazone can be purchased in tablet form. One or two tablets will sterilize a quart of ordinary contaminated water. Full directions accompany each bottle of halazone tablets. Halazone could be used to disinfect cistern water obtained from irrigation ditches.

Sanitation of Domestic Ice Supplies.

An adequate supply of pure ice should be available for all city and country homes. The proper preservation of foods in the home and of dairy products on the farm requires the use of ice in properly constructed refrigerators.

Water formed by melting ice is a safer and more wholesome supply of drinking water than can be obtained from wells in some localities. This is particularly true in regions where underground water supplies have a high mineral or alkali content. Ice water contains little or no mineral matter in solution. Clean ice can be stored in a large concrete cistern and the water resulting from the melting of the ice can be collected for use. A small portion of the floor

of the cistern can be made of porous material and serve as a filter through which the water passes by gravity to another concrete cistern used for storage. Water can be pumped from the storage cistern direct to the kitchen as needed.

When ice water is used for drinking because the underground water of the locality is unfit for domestic use due to the alkali, the maximum amount of acceptable water can be obtained by using the ice water for the purpose of lowering the concentration of the alkali of the underground water by dilution. For instance an alkali water containing 3000 parts of mineral salts per million parts of water might be unfit for drinking. If one quart of such a water is added to two quarts of ice water, the resulting mixture of three quarts would contain 1000 parts of mineral salts per million. An alkali water of this concentration would be acceptable to most people.

Sources of Ice. There are a number of plants in the state which manufacture artificial ice for the market. For the most part, the ice supplies of Montana are obtained by harvesting natural ice from ponds, lakes and rivers.

There is a general popular impression that natural ice should only be harvested from sources of water that are pure enough for drinking. A study of all the factors of ice formation shows plainly that this is not necessary. Facts cited in another section will indicate that safe ice can be harvested, under certain well defined conditions, from lakes, ponds and rivers containing a moderate amount of pollution. This is fortunate because it is seldom possible to find bodies of water suitable for ice formation above all sources of pollution. This is true even in a mountainous state like Montana.

The usual mountain stream at points above all sources of pollution is too small and the flow of water too rapid for successful ice formation. The only water courses on which ice can be properly formed are the larger slow flowing streams of the inhabited valleys. Such streams always receive more or less pollution.

The lakes or ponds in the mountains above human habitations which are entirely free from pollution are not conveniently located for harvesting ice. Lakes and ponds of this character are too far from market centers and transportation of the ice would be too expensive. It follows that the available natural ice fields are situated in inhabited valleys reasonably near market centers and in consequence of their location are subject to more or less pollution.

The practice of harvesting ice from sources of water containing moderate amounts of pollution raises questions relating to the rights of the consumer and the privileges of the producer. The consumer is entitled to ice that is pure

and safe for all domestic uses. Safeguarding public health is obviously of paramount importance.

On the other hand, the producer should be allowed to select fields from which safe ice can be conveniently and economically produced. It is apparent that it would work a hardship on the ice industry to insist that all water used for the formation of natural ice should be pure enough for drinking. These facts invite a full consideration of the facts involved in the natural purification of water by freezing. With these facts at hand, reasonable regulations governing the safe operation of ice fields can be formulated.

Natural Purification of Water by Freezing. There are three factors which tend to bring about a natural purification of a polluted water in freezing. These factors are crystallization, temperature, and time.

In general, crystallization is a purifying process. The formation of crystals takes place under the action of natural forces which tend to exclude impurities. However, these forces are only effective when there is free water beneath the ice. If a pond of polluted water is frozen solid, the impurities in the water will be included in the ice. Naturally some of the germs included in the ice would be destroyed by the low temperature of freezing.

When there is about three feet of free water beneath the ice, the formation of ice crystals will proceed in such a way as to exclude a large proportion of the bacteria and also many of the impurities in solution. Therefore, ice should not be harvested from shallow ponds and rivers that freeze solid or nearly so.

It follows that the practice of flooding ice ponds to hasten the formation of an adequate thickness of ice is a dangerous practice. Impurities in the water used for flooding would be included in the ice.

The low temperature of freezing is the second factor in the natural purification of ice. The natural habitat of the germs which cause the usual water borne diseases such as typhoid fever and dysentery is the intestinal tract of man. It follows that the water of an ice pond is not a favorable media for the growth and development of these germs. This fact is the cause of another large reduction in the number of germs found in ice harvested from a polluted source.

The element of time is the third important factor. Natural ice is usually stored a number of weeks or even months before it is used for human consumption. The effect of time on the number of germs in stored ice is indicated by Professor Jordan who says, "All investigators are now agreed that three weeks after freezing, less than one per cent and possibly less than one-half of one per cent remain alive."

It is desirable to have a practical measure of the degree of purification that can be normally expected, when ice is formed from polluted water. Professor G. C. Whipple of Harvard University has given a satisfactory basis for an opinion on this point. "The results correspond roughly with the purification that takes place in a water filtration plant. It may be said, therefore, speaking broadly, that the water that may be safely used after filtration may also be safely used after natural freezing, if it is not interfered with by tapping or flooding."

The Danger in Ice. The previous discussion indicates that nature has provided three forces which are effective in purifying ice, viz, crystallization, temperature and time. However, it should be clearly understood that these forces must operate under certain well defined conditions in order to be effective. It must be recognized that there are limiting factors to the effective operation of these forces. Hence, it must not be concluded that there is no danger of ice conveying diseases.

While it is true that clear ice formed on properly operated ice fields is usually safe for human consumption, still the fact remains there are some real dangers in ice.

The greatest danger, however, comes from improper handling especially at times of delivery to the consumer and also when ice is prepared for table use. Delivery men sometimes drag cakes of ice across dirty sidewalks and floors. Ice for table use is often handled with unclean hands. Ice which is to come in direct contact with articles of food should be washed with clean water in proper containers and drained without coming in contact with the hands. The ice can be distributed for table use by a large spoon or ladle.

Operation of Ice Fields. The Montana State Board of Health has conducted many laboratory and field investigations of the natural ice supplies of the state. The accuracy of the foregoing statements in this bulletin have been carefully verified by experience through a number of years. The investigations to date have failed to demonstrate that ice is an important factor in the spread of communicable diseases in Montana.

However, it should be recognized that perfectly safe ice can only be delivered to the consumer by operating ice fields properly and by the use of sanitary methods in the delivery and handling of ice.

The Montana State Board of Health considers that safe ice can be produced under the following conditions:

(1) The water used for ice formation should be reasonably free from pollution. A water that can be purified satisfactorily for drinking by sand filtration, is broadly speaking, safe for ice making. According to this standard certain

ponds and many streams in inhabited valleys can be safely used for ice formation. Ice fields should not be located on rivers near sewer outlets or on grossly polluted ponds.

(2) The depth of water beneath the ice field should be at least three feet at the time of harvesting. The forces involved in purifying water by crystallization can operate effectively under this condition.

(3) The ice field should not be flooded by tapping the ice or flooded by water from the inlet to the ice field. By this method of building up the ice sheet, impurities are included in the ice.

(4) Only clear ice free from foreign material should be stored for subsequent use. All snow ice, and parts which are not perfectly clear should be discarded.

(5) The harvesting process should be conducted under sanitary conditions, and no ice should be stored which has been contaminated with animal or human excreta.

(6) The delivery of ice to the consumer should be done under sanitary conditions. Cakes of ice should not be drawn across sidewalks and dirty floors. Ice which is to be used for human consumption should not be handled with unclean hands. In fact this constitutes the chief danger in ice.

Storage of Ice. For information on the harvesting and storing of ice and on the construction of icehouses, the reader is referred to Circular 59, Montana Agricultural Experiment Station, by H. E. Murdock. A copy of this circular can be obtained by addressing the Director of the Experiment Station, Bozeman.

Investigations of Ice Supplies. It is plain from the foregoing discussion that ice fields can be selected and operated in such a way as to produce safe and sanitary ice with little or no technical assistance or advice. The underlying principles governing the production of safe ice are extremely simple.

Therefore, the Montana State Board of Health believes that it is not necessary to spend public funds for periodic laboratory and field investigations of all ice supplies in the state.

Occasionally investigations are made when there are some unusual features connected with the location or operation of any given ice fields.

The local health officer in each community can assume the responsibility of insisting that the ice producers under his jurisdiction follow the simple principles involved in the production of safe ice for all domestic uses.

Regulations of the State Board of Health Relating to Sanitary Investigations of Private Water Supplies. Functions of the State Board of Health Water Laboratory. The State Board of Health is charged with the responsibility of enforcing all state laws relating to the sanitary qualities of public and private water supplies. This responsibility also involves many problems relating to policies governing disposal of city sewage and the pollution of waterways. In order to enforce these laws, and the authorized sanitary regulations promulgated under these laws, it is necessary for the State Board of Health to base executive decisions to a large measure on the results of laboratory and field investigations.

Sanitary Investigations of Public Water Supplies. Chapter 126, Session Laws 1917, is an act which gives the State Board of Health, the power to require the analysis of water furnished and sold to the public, and to provide rules and regulations governing periodic investigations of all public water supplies in the state. The bill also provides for funds to cover the cost of conducting the investigations required in the enforcement of this law.

The field and laboratory work required under this law has been carefully organized. Periodic physical inspections of all water plants are made and frequent laboratory investigations are conducted. Complete reports are furnished to the parties directly responsible for the operation of the various public water supplies.

Sanitary Investigations of Private Water Supplies. While the State Legislature made special provisions in the State Board of Health appropriation for investigations of the sanitary qualities of public water supplies, comparatively, only a small part of the appropriation is available for studying private water supplies.

It is, therefore, necessary to place some restrictions on the examination of water samples from private supplies and the major portion of the money available must be spent on investigations of city and town supplies where many people obtain water from a common source. In this way, the greatest benefit can be obtained for the largest number of people.

However, the State Board of Health recognizes the importance of giving citizens of the state as much information as possible on the potability of private water supplies. In order to impart this information and at the same time keep the cost of operating the laboratory within the amount of available funds, it has been necessary to adopt some regulations.

Regulations Governing Laboratory Examinations of Private Water Supplies.

General Policies. Laboratory examinations of water samples from private supplies will only be made on the recommendation of the local health officer under whose jurisdiction the same occurs or of a regular representative of the water and sewage division of the State Board of Health.

Before a health officer makes a recommendation, he should satisfy himself that laboratory tests are really necessary, by first making a physical examination of the environment of the supply from the sanitary aspect. This will eliminate the necessity of making analyses for the purpose of satisfying curiosity only.

Sanitary Inspection of Private Water Supplies. When a health officer makes an inspection of the physical environment of a private water supply, he should keep in mind, the principles of sanitary science applied to water supplies as given in previous sections of this circular. The inspection should be made to determine the possibility of excreta reaching the water supply. In this connection, it would be necessary for the health officer to consider the environment surrounding the supply, its location, construction and operation. The points that he will find necessary to apply in this connection have been discussed and illustrated.

Special Information for the Health Officer. After a health officer has made a careful inspection of a given water supply, he should decide whether a laboratory investigation is really necessary before he makes a recommendation.

If the inspection clearly indicates that there is no danger of excreta reaching the water supply, a sanitary analysis is not necessary. The water will be pure from the sanitary aspect. It would be a waste of time and labor to make a laboratory examination of water samples in such a case.

If it is apparent from the field inspection that the water supply could become contaminated with excreta because of faulty construction of the water system or because of an insanitary method of sewage disposal, still a laboratory investigation may not be necessary. All that may be required under such conditions is to order the changes in construction, location and environment that are necessary to remove all danger of future contamination reaching the water supply. The procedure to recommend will often be very evident.

If the health officer finds that there is even a remote possibility of a water supply being unsafe for drinking, he should immediately order that the water be purified, in accordance with the instructions already given until he is satisfied that the changes he has ordered have been made in such a way as to adequately protect the water supply

from future contamination. In this way, it may be perfectly safe to omit a laboratory investigation.

If the health officer feels that it is necessary to have a laboratory examination of water samples to supplement his field inspection data, he should then make an application to the State Board of Health for sample containers and explain fully the details of his problem. Complete directions for sampling will be furnished by the laboratory.

Information for Owners of Private Water Supplies.

The general information in this circular indicates that it is a simple matter to apply the principles of sanitation in such a way as to keep a private water supply safe for drinking. The responsibility should rest with the individual owner and cannot be assumed by the state.

The owner should appreciate that it is his responsibility to see that his source of water supply has a sanitary environment, as well as a safe location and that it is protected by a proper construction. These details attended to in proper fashion, will keep excreta from reaching the water which will then be safe for drinking.

When the owners assume this responsibility it is unnecessary for the State Board of Health to conduct laboratory investigations of private water supplies. Further, water samples to be of real value must be collected by a person who is properly trained. The operations of collecting and shipping water samples and the recording of field inspection data so necessary a part of the entire investigation, must all be performed by a person who is properly trained to conduct water investigations. For this reason, the State Board of Health does not make a practice of sending containers to private individuals for sampling private water supplies. Whenever possible, specially trained investigators of the Board of Health staff are sent out to conduct sanitary surveys of water supplies and to take the samples required. These field men cooperate with local and county health officers who represent the State Board of Health in water supply investigations in their various communities.

It must be evident that it is far more advisable to depend on inspection data of a private water supply, than upon an occasional laboratory test. The field data shows plainly, the chances for future contamination of a water supply while the laboratory data only gives information on conditions at the time of sampling. A favorable laboratory test often gives a false sense of security not warranted at all by an inspection of the surroundings of the supply from the sanitary aspect. This is another excellent reason for limiting laboratory examinations of private water supplies.

Summary.

(1) Human excreta is dangerous. It contains germs or living poisons which cause the following diseases: "typhoid fever, dysentery, Asiatic cholera, tuberculosis, hookworm, eelworm, and tapeworm diseases."

(2) Human excreta may be spread around by various means. "By water, through surface washing or subsoil seepage by the hands or feet of persons or by animals. By flies and other insects."

(3) To avoid the diseases caused by the germs in excreta, it is necessary to prevent the spread of human filth so that it cannot reach the mouths of persons through direct contact or by foods or water.

(4) The proper disposal of excreta involves the construction of sanitary sewage systems or of sanitary privies.

In general the only type of privy to be recommended as sanitary is that provided with water tight receptacles to receive the excreta and so constructed that flies cannot have access to the excreta."

The so-called "pit-privies" cannot be classed as sanitary. This type contaminates the surrounding soil which is easily spread.

"In advocating privies for use in the disposal of human excreta, not only proper construction, but also proper upkeep and proper use of the same and proper disposal of contents, should be urged."

(5) The principles underlying pure water supplies are extremely simple.

(a) Surface waters below human habitations cannot be recommended for public consumption without purification. It is a dangerous practice to drink unpurified water from irrigating ditches and other surface streams in inhabited valleys.

(b) Mountain streams above habitations supplied from watersheds not frequented by pleasure seekers or campers or used for pasturing animals are usually safe sources of supply for domestic use if all chances for accidental pollution are prevented by proper policing.

(c) Underground waters of a large uninhabited area are free from contamination and are safe for domestic use from the sanitary aspect.

(d) If underground waters are to be maintained in their original state of purity, it is necessary to prevent their contamination by properly constructed and operated sewage disposal devices. The problem also involves the proper location, construction and operation of wells from which ground waters are drawn for domestic use.

(e) When the application of the principles of sanitation to a private water supply indicates that the supply is unsafe for domestic use, it is possible to purify water in small quantities by boiling and by chemical disinfection. Purification should be continued until the water supply can be investigated and made perfectly safe by changes in environment, location or construction. A carefully conducted physical examination of a private water supply will usually indicate what changes are necessary in the environment to prevent excreta from reaching the water.

(6) The State Board of Health does not attempt to conduct periodic investigations of private water supplies. Investigations of private water supplies are only made on recommendations of local health officers. Containers for water samples are not shipped to private individuals but to local health officers.

(7) The use of sanitary ice in the home is recommended for a variety of reasons. Safe ice can be harvested from sources of water containing moderate amounts of pollution under well defined conditions. The chief danger in ice comes from improper handling.

The State Board of Health does not conduct systematic investigations of ice supplies.

WHEN VACCINATION PROTECTS, WHY TAKE CHANCES?

What Is Typhoid Fever?—It is a serious, contagious, infectious disease, lasting from four to eight weeks, or longer. There are often serious complications, such as ulcers, hemorrhage, or perforation of the bowel. In about one out of every ten cases the patient dies. It is estimated that about 25,000 persons die of typhoid fever in this country every year. And yet it is a preventable disease.

How Is It Spread?—Always by swallowing typhoid germs which have come from the discharges of human being. Such a person may be a patient ill with typhoid fever or be what is known as a "typhoid carrier," a person who has recovered but who continues to discharge the germs in the urine or feces. Hence, typhoid fever is a "filth" disease. Infected water, milk, and food, dirty fingers, and filthy flies often spread the disease.

Can Typhoid Fever Be Prevented?—Yes; by good sanitation, personal cleanliness, and by vaccination.

What Is Typhoid "Vaccination"?—This vaccine is harmless. Three doses are injected under the skin of the arm at intervals of about one week. After each dose there may be slight swelling and tenderness. Sometimes a little headache, lasting about 24 hours. This "vaccination" produces an "immunity" or protection which lasts from one to four years, sometimes longer. There is absolutely no risk and no danger.

Why You Should Be Protected—Because this is a disease of poor sanitation. You can't always protect yourself from the carelessness of others. Vaccination offers a simple and safe means of protection. If you have not had the disease get vaccinated today. Why take chances with such a serious disease?

Can you afford to lose from four to eight weeks' pay? Do you prefer to employ a nurse and doctor for a long siege of typhoid fever? Do you know what a case of typhoid costs in money and suffering? Ask some one who has had it.

VACCINATION SAVES LIVES, WHY NOT YOURS?

—U. S. Public Health Service.

FACTS TO BE REMEMBERED

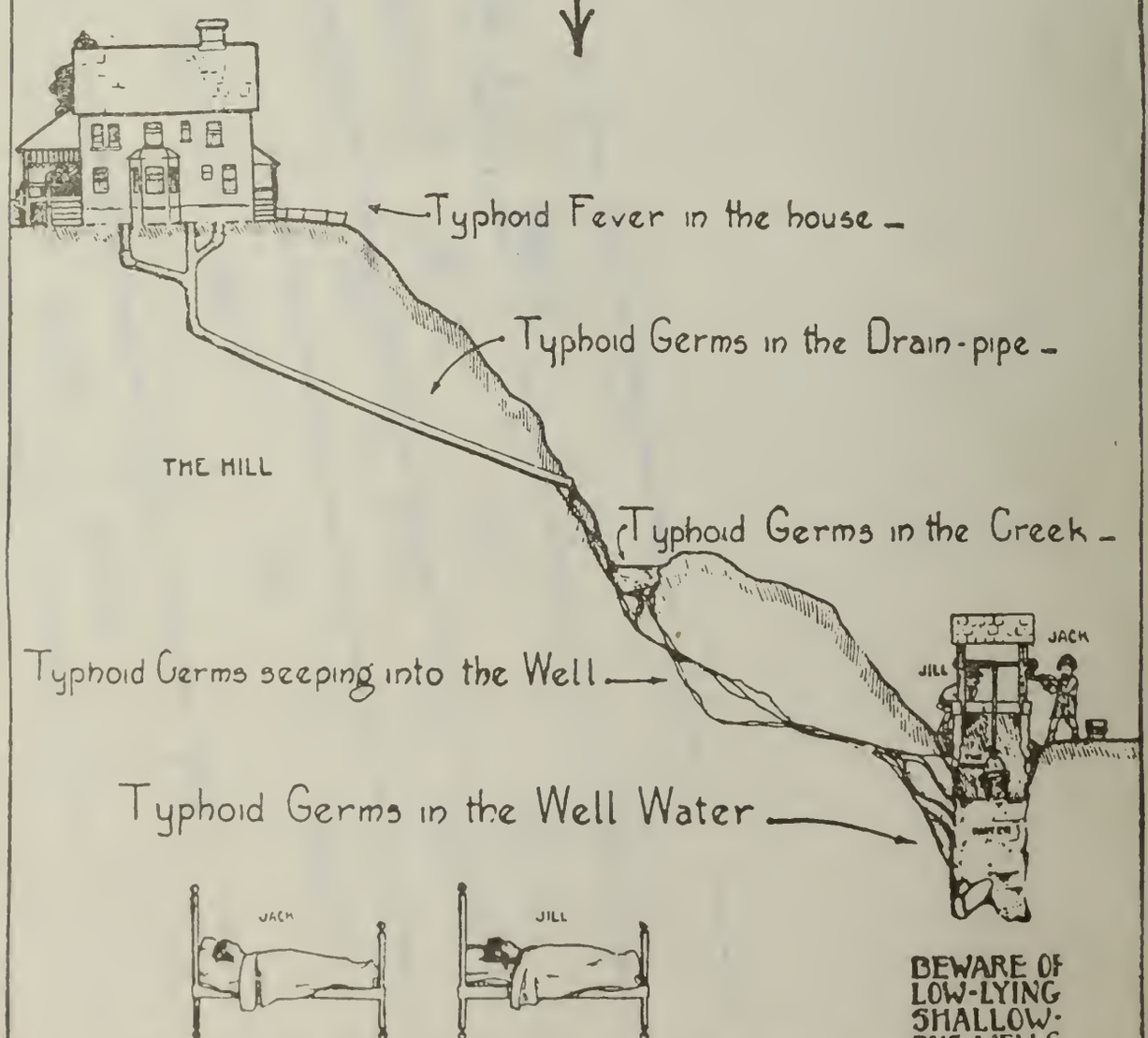
1. Pure water is a luxury.
2. Pure water is a necessity.
3. Pure water is cheap.
4. Impure water is dangerous.
5. Impure water is expensive.
6. Ground-waters must be protected.
7. Surface-waters must be purified.
8. Qualities to be sought in water—
   wholesomeness, cleanliness and softness

JACK AND JILL.

JACK AND JILL
WENT DOWN THE HILL
TO GET A DRINK OF WATER

JACK FELL SICK
OF TYPHOID, QUICK,
AND JILL CAME FOLLOWING AFTER!

— AND THIS IS THE REASON WHY



BEWARE OF LOW-LYING SHALLOW-DUG WELLS

TYPHOID GERMS IN JACK AND JILL !

Chicago Health Department - Educational Poster No 234

KATHERINE FIELD WHITE - 1914